REMARKS

Claims 1, 7, 13 and 17 have been amended to overcome the 35 U.S.C. § 112, first and second paragraph, grounds rejection and to precisely define the layered product of the present invention in terms which distinguish over the product of Obara, JP 07-047152, as modified by Nishimura et al., JP 07-112039 ("Nishimura"), and over Igakura et al., JP 09-277420 ("Igakura") as modified by Obara and Nishimura.

Specifically, the claims have been amended to change the recitation "maximum thickness" to --thickness-- in claims 1 and 17; to delete the recitations "resin constituting said thermosetting resin layer is not mixed with a resin constituting said thermoplastic resin layer", "resin constituting said thermoplastic resin layer is not mixed with a resin constituting said thermosetting resin layer", and "substantially parallel" in claims 1 and 17; to change the recitation "layered product as a molded object" in claims 1 and 17 to simply --layered product--; to change the recitation "layered product as a molded object" in claim 7 to --molded object-; and to properly recite the Markush group in claim 13.

Claims 1 and 17 now define the layered product of the invention in the following terms:

"layered product having first and second opposed surfaces and comprising:

a thermosetting resin layer forming the first opposed surface of the layered product,

a thermoplastic resin layer forming at least part of the second opposed surface of the layered product, and

reinforcing continuous filaments arranged in one direction in said layered product and existing in both the thermosetting resin layer and the thermoplastic resin layer,

wherein

the thermoplastic resin layer and the thermosetting resin layer are integrated at a continuous rugged interface between said layers,

said continuous rugged interface having a structure such that some of said reinforcing continuous filaments parallel to the surface of the layered product extend through said continuous rugged interface and exist in the resin of said thermoplastic resin layer and also exist in the resin of said thermosetting resin layer, and

wherein

the thickness of an area in said thermoplastic resin layer between an outermost reinforcing continuous filament with respect to the surface of the thermoplastic resin layer and an innermost reinforcing continuous filament with respect to the surface of the thermoplastic resin layer is 10 μm or more."

Finally, a new claim 39, has been added to the application to provide an alternative definition of the layered product of the present invention.

Prior to discussing the objections and rejections in the Action, applicants note that a personal interview was conducted on December 23, 2009, between the Examiner, Mr. Gerard T. Higgins, and applicants' undersigned representative. During the interview, the proposed amendments to claim 1 and new claim 39 were discussed in light of the differences between the product of Obara and the layered product of the present invention. Photographs of an enlarged cross-section of a layered product produced according to the method described in Example 3 of Obara and of a cross-section of the layered product of the present invention were shown to Mr. Higgins.

Further matters discussed during the interview are indicated

below in the remarks relating to the 35 U.S.C. § 103(a) rejections made in the Action.

Referring to the Action, the specification disclosure and claims 1 and 17 are objected to relating to the expression "the maximum thickness of an area … is 10 microns or more." The Examiner suggests in the Action that the specification and claims be amended to correct this expression because no maximum is recited.

Applicants request that the objection to the specification be held in abeyance pending a determination of allowable claims in the application. The term "maximum" is not recited in amended claims 1 and 17.

Claims 1, 3, 5-8, 11-13, 16, 17, 19 and 20 are rejected under the first paragraph of 35 U.S.C. § 112 as failing to comply with the written description requirement. The expressions in the claims that form the basis for this rejection have been deleted from the claims as explained above. The claims as amended satisfy the requirements of the first paragraph of 35 U.S.C. § 112.

Claims 1, 3, 5-8, 11-13, 16, 17, 19 and 20 are also rejected under the second paragraph of 35 U.S.C. § 112 as being indefinite.

The claims as amended do not include the terms and expressions that are identified in the rejection as being

indefinite except that the term "rugged", identified in the rejection as being indefinite, has been retained in the claims. Applicants submit that the term "rugged", albeit broad, is not indefinite when read in light of the language of the claims and in light of the specification, as it must be according to United States law. In its broadest sense, the term means not straight. However, the recitations in claim 1 of:

> "said continuous rugged interface having a structure such that some of said reinforcing continuous filaments parallel to the surface of the layered product extend through said continuous rugged interface and exist in the resin of said thermoplastic resin layer and also exist in the resin of said thermosetting resin layer"
>
> and
>
> "the thickness of an area in said thermoplastic resin layer between an outermost reinforcing continuous filament with respect to the surface of the thermoplastic resin layer and an innermost reinforcing continuous filament with respect to the surface of the thermoplastic resin layer is 10 μm or more",

and the recitations in claim 39 of:

> "(f) said continuous rugged interface is formed between

an innermost filament in the resin of said thermoplastic resin layer in the region where the thickness of the resin of said thermoplastic resin layer from the surface of said thermoplastic resin layer is largest and an outermost filament in the resin of said thermoplastic resin layer in the region where the thickness of the resin of said thermoplastic resin layer from the surface of said thermoplastic resin layer is smallest",

and

"(g) a distance between an outermost filament in said filaments in the resin of said thermoplastic resin layer in the thickness direction thereof and the innermost filament in said filaments in contact with the resin of said thermoplastic resin layer in the region where the thickness of the resin of said thermoplastic resin layer from the surface of said thermoplastic resin layer is largest is 10 μm or more",

serve to further define the interface and exclude a straight interface such that a person of ordinary skill in the art would understand the scope of the claims. Nothing more is required under the second paragraph of 35 U.S.C. § 112.

Therefore, the claims as amended satisfy the requirements of the second paragraph of 35 U.S.C. § 112.

Claims 1, 3, 5-8 and 11-13 are rejected under 35 U.S.C. § 103(a) as obvious over Obara, JP 07-047152, machine translation, in view of Nishimura et al., JP 07-112039 ("Nishimura"). Claims 16, 17, 19 and 20 are rejected under 35 U.S.C. § 103(a) as obvious over Igakura et al., JP 09-277420 ("Igakura") in view of Obara and Nishimura.

Prior to discussing these rejections, applicants note that they are submitting an English translation of Obara prepared by a human translator with this response. The translation is clear and it is requested that this translation be made of record and substituted for the machine translation of Obara.

During the interview on December 23, 2009, as noted in the Interview Summary prepared by Examiner Higgins at the conclusion of the interview, Examiner Higgins and the undersigned discussed how Obara's "interface" differs from that of the present claims. This difference was discussed in light of the photographs of enlarged cross-sections of the respective products shown to Examiner Higgins during the interview and the drawings of the present specification. It was noted that the thermoplastic resin layer and the thermosetting resin layer of the layered product of the present

invention are integrated at a continuous rugged interface. On the other hand, there is no interface of a thermosetting resin layer and a thermoplastic resin layer in the product of Obara or at least there is nothing that can be characterized as a continuous interface between a thermosetting resin layer and a thermoplastic resin layer. Obara itself distinguishes the "domain" of its product where the thermosetting resin and the thermoplastic resin are "intermingled" (Example 3) (page 13, lines 6-9, of the accompanying English translation) and an "interface" between the thermosetting resin and the thermoplastic resin in a comparative product (Comparative Example 2) (page 13, paragraph [0026] of the accompanying English translation).

In view of the differences between the product of Obara and that of the present invention noted during the interview, the claims of the present application have been amended to define the interface of the layered product of the present invention as a "continuous rugged interface". This limitation is supported in at least the drawings of the present application.

The claims as amended, i.e., claims 1, 3, 5-8 and 11-13, are believed to be patentable under 35 U.S.C. § 103(a) over Obara in view of Nishimura and overcome the 35 U.S.C. § 103(a) rejection of these claims.

Regarding the 35 U.S.C. § 103(a) rejection of claims 16, 17, 19 and 20, claims 16, 19 and 20 include a layered product according to claim 1. Claim 17 recites a layered product in the same terms as recited in claim 1. Since the layered product of claim 1 has been shown to be patentable under 35 U.S.C. § 103(a) over Obara in view of Nishimura, claims 16, 17, 19 and 20 are also patentable under 35 U.S.C. § 103(a). Therefore, the 35 U.S.C. § 103(a) rejection of claims 16, 17, 19 and 20 is also overcome.

A notice of allowability of the present application is respectfully requested.

As a final comment, applicants extend their gratitude to the Examiner, Mr. Higgins, for his courtesy extended to their undersigned representative during the interview on December 23, 2009.

The foregoing is believed to be a complete and proper response to the Office Action dated June 24, 2009, and is believed to place this application in condition for allowance.

In the event that this paper is not considered to be timely filed, applicants hereby petition for an appropriate extension of time. The fee for any such extension may be charged to our Deposit Account No. 111833.

In the event any additional fees are required, please also

charge our Deposit Account No. 111833.

Respectfully submitted,

KUBOVCIK & KUBOVCIK

Ronald J. Kubovcik
Reg. No. 25,401

Crystal Gateway 3
Suite 1105
1215 South Clark Street
Arlington, VA 22202
Tel: (703) 412-9494
Fax: (703) 412-9345
RJK/ff

Atachment: English translation of Obara (JP 07-047152A)

English translation of Obara JP 07-047152 A

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Applicant:: Asahi Chemical Industries, Co., Ltd.

Inventor: OBARA Kazuyuki

[Title of the Invention] FIBER REINFORCED RESIN RACKET FRAME

[Abstract]

[Object] To provide a fiber reinforced resin racket frame which is excellent in vibration attenuation property, better in ball hitting touch and free from environmental change while keeping a sufficient practical strength, rigidity and durability.

[Constitution] A fiber reinforced resin racket frame comprising a fiber reinforced thermosetting resin and a fiber reinforced thermoplastic resin, wherein an area where a thermosetting resin and a thermoplastic resin, or a thermosetting resin, a thermoplastic resin and reinforcing fibers are intermingled with each other exists at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[Claims]

[Claim 1] A fiber reinforced resin racket frame comprising a fiber reinforced thermosetting resin and a fiber reinforced thermoplastic resin, wherein a thermosetting resin and a thermoplastic resin are intermingled with each other at least at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[Claim 2] A fiber reinforced resin racket frame comprising a fiber reinforced thermosetting resin and a fiber reinforced thermoplastic resin, wherein a thermosetting resin, a thermoplastic resin and reinforcing fibers are intermingled with each other at least at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[Detailed description of the invention]

[0001]

[Field of industrial application] The invention relates to a frame which constitutes a racket used for tennis, badminton, squash, etc.

[0002]

[Prior art] In recent years, racket frames made of fiber reinforced resin have gained the mainstream because of its features such as lightweight, high rigidity, high strength and durability. Most of reinforcing fibers used therein are long fibers, short fibers, whiskers, etc. and most of matrix resins used therein are thermosetting resins such as epoxy, while thermoplastic resins such as nylon and polyphenylene ether are used in some products.

[0003] Usually, a racket frame is fabricated in one form from a thermosetting resin reinforced with fibers having a high strength and a high elastic modulus, such as carbon fibers. Due to its high rigidity, such a frame is likely to suffer vibrations when receiving an impact to cause damage to an elbow of a player. In some racket frames developed in recent years, a fiber reinforced thermoplastic resin comprising long fibers for reinforcement is used to exploit its high ductility to develop good characteristics such as high impact resistance and vibration damping capacity that cannot be achieved in the conventional racket frames made of

thermosetting resin. As compared with thermosetting resins, however, thermoplastic resins generally have the disadvantage that their elastic modulus is highly dependent on the environment and that their characteristics such as rigidity can change easily depending on the use conditions of the racket frame.

[0004] In JP 1-121074 A, a production of a racket frame comprising a long-fiber reinforced thermoplastic resin having high vibration damping capacity and a long-fiber reinforced thermosetting resin whose characteristics are not significantly dependent on the environment is disclosed. When both thermoplastic resin and thermosetting resin are used as a matrix resin, a sufficiently high affinity cannot always be achieved between the two resins, leading to insufficient adhesiveness at the interface between them. It will be necessary, therefore, to effectively control the affinity between them and the structure at the interface to ensure a required adhesiveness at the interface between the two resins.

[0005] JP 1-121074 A, however, only describes that the matrix of long-fiber reinforced thermoplastic resin melts or softens as the long-fiber reinforced thermosetting resin is cured, leading to good contact, suggesting that it will be impossible to achieve interface adhesion required to maintain a sufficient durability in a racket frame that suffers repeated impacts. Furthermore, the racket frame will be inferior in heat resistance if the melting point and/or the softening point of the thermoplastic resin are lower than the curing temperature of the thermosetting resin.

[0006]

[Problems to be solved by the invention] The invention provides a fiber reinforced resin racket frame having high vibration damping capacity and good feel at impact and suffering little change in characteristics under varying use conditions while maintaining sufficient practical strength, rigidity and durability.

[0007]

[Means of solving the problems] A fiber reinforced resin racket frame the invention comprises

a fiber reinforced thermosetting resin and a fiber reinforced thermoplastic resin, wherein an area where a thermosetting resin and a thermoplastic resin or a thermosetting resin, a thermoplastic resin and reinforcing fibers are intermingled with each other exists at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[0008] Resins that can be used as a matrix resin in the fiber reinforced thermosetting resin in the invention include various thermosetting resins such as epoxy resin, unsaturated polyester resin, phenol resin, and polyimide resin, of which epoxy resin is preferable. Reinforcing fibers that can be used as reinforcing fibers in the fiber reinforced thermosetting resin in the invention include known fibers having high strength and high elastic modulus such as carbon fibers, glass fibers, aramid fibers, silicon carbide fibers, alumina fibers, etc. and combinations thereof, of which carbon fiber is the most preferable because of its reinforcing efficiency and light weight. As the reinforcing fibers, long fibers, short fibers, and whiskers may be used, of which long fibers are preferable because of its reinforcing efficiency.

[0009] Resins that can be used as a matrix resin in the fiber reinforced thermoplastic resin in the invention include polyolefin resin, polyester resin, polyamide resin, acrylic resin, polyoxy methylene resin, polycarbonate resin, polyphenylene ether resin, polystyrene resin, polyether ketone resin, polyether ether ketone resin, polyethersulfone resin, polyphenylene sulfide resin, polyetherimide resin, etc. These may be in the form of a copolymer, alloy, blend, or compound.

[0010] The melting point or softening point of the matrix resin in the fiber reinforced thermoplastic resin should preferably be above the temperature at which the viscosity of the matrix resin in the fiber reinforced thermosetting resin reaches the minimum while the resin is still in the uncured state, more preferably not less than the minimum viscosity temperature and not more than 300°C. The aforementioned temperature range is preferred in view of a molding temperature, an interface control at a time of molding, and physical properties of a

molded product. To prevent the characteristics of the racket frame from being changed due to water absorption, the water absorption coefficient of the matrix resin in the fiber reinforced thermoplastic resin as measured according to ASTM D570 should preferably be 1.5% or less, more preferably 0.5% or less.

[0011] As the matrix resin in the fiber reinforced thermoplastic resin, the preferred materials include polypropylene resin, oxidation-cracked modified polypropylene resin, acid-modified polypropylene resin, and copolymers, alloys, blends and compounds comprising polypropylene resin, oxidation-cracked modified polypropylene resin or acid-modified polypropylene resin, which have a melting point and water absorption coefficient in the aforementioned range, have a glass transition point not more than room temperature, and have a particularly high vibration damping capacity at room temperature among other thermoplastic resins. Particularly preferred ones include oxidation-cracked modified polypropylene resin, acid-modified polypropylene resin, and copolymers, alloys, blends and compounds comprising oxidation-cracked modified polypropylene resin or acid-modified polypropylene resin, which show high adhesiveness with other resins and reinforcing fibers.

[0012] Reinforcing fibers that can be used as reinforcing fibers in the fiber reinforced thermoplastic resin in the invention include known fibers having high strength and high elastic modulus such as carbon fibers, glass fibers, aramid fibers, silicon carbide fibers, alumina fibers, etc. and combinations thereof, of which carbon fiber is the most preferable because of its reinforcing efficiency and light weight. As the reinforcing fibers, long fibers, short fibers, and whiskers may be used, of which long fibers are preferable because of its reinforcing efficiency. The long fibers are substantially continuous fibers or discontinuous fibers having a length of 5 mm or more. As a form of reinforcing long fibers, an article in which fibers are substantially uni-directionally arranged in the lengthwise direction of the fibers, a woven fabric, random mat, etc. may be used, of which article comprising fibers substantially uni-directionally arranged in the lengthwise direction of the fibers is preferable because it can serve most

effectively to reinforce the matrix resin.

[0013] As a material for forming the fiber reinforced thermoplastic resin, one of the following materials can be used. A thermoplastic resin pellet including discontinuous long fibers, short fibers, whiskers, etc.; so-called stamping sheet produced by impregnating a random mat with a thermoplastic resin; an article produced by impregnating a long-fiber woven fabric with a thermoplastic resin; an article produced by impregnating a material comprising fibers substantially uni-directionally arranged in the lengthwise direction of the fibers with a thermoplastic resin; a braid or cord fabric comprising fiber bundles produced by arranging in one direction or intermingling reinforcing long fibers and thermoplastic long fibers; a woven fabric comprising reinforcing long fibers or the aforementioned fiber bundles produced by arranging in one direction or intermingling reinforcing long fibers and thermoplastic long fibers used as warp yarns, and thermoplastic long fibers used as weft yarns; a composite sheet comprising a sheet comprising an aggregate of reinforcing long fibers substantially uni-directionally arranged in the lengthwise direction of the fibers and a sheet comprising thermoplastic fibers wherein the thermoplastic fibers are entered between the reinforcing long fibers and interlaced and integrated therewith; a braid produced by processing the composite sheet into a tube, etc. The use of a composite sheet comprising a sheet comprising an aggregate of reinforcing long fibers substantially uni-directionally arranged in the lengthwise direction of the fibers and a sheet comprising thermoplastic fibers wherein the thermoplastic fibers are entered between the reinforcing long fibers and interlaced and integrated therewith or a braid produced by processing the composite sheet into a tube is preferable in view of its high handleability, easy impregnation of the thermoplastic resin at a time of molding, and high reinforcing efficiency. Generally known methods can serve to produce the aforementioned various molding materials for the fiber reinforced thermoplastic resin.

[0014] In the invention, it is required that the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin are coexisted with each other in one racket frame. States of

existing of the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin are not particularly limited. For instance, there is a state in which a frame portion comprises the fiber reinforced thermoplastic resin and a grip portion comprises the fiber reinforced thermosetting resin, or a frame portion comprises the fiber reinforced thermosetting resin and a grip portion comprises the fiber reinforced thermoplastic resin. In a cross section of the racket frame, for instance, there is an existing state in which a foamed synthetic resin - a fiber reinforced thermoplastic resin - a fiber reinforced thermosetting resin are laminated in this order from the inner layer or a foamed synthetic resin - a fiber reinforced thermosetting resin - a fiber reinforced thermoplastic resin are laminated in this order from the inner layer, or there is an existing state in which a thermoplastic resin tube - a fiber reinforced thermoplastic resin - a fiber reinforced thermosetting resin are laminated in this order from the inner layer or a thermoplastic resin tube - a fiber reinforced thermosetting resin - a fiber reinforced thermoplastic resin are laminated in this order from the inner layer, or there is an existing state in which a fiber reinforced thermoplastic resin - a fiber reinforced thermosetting resin are laminated in this order from the inner layer or a fiber reinforced thermosetting resin - a fiber reinforced thermoplastic resin are laminated in this order from the inner layer. The abovementioned existing states in a cross section of the racket frame may either exist along the entire length of the racket frame or a part, for example only the frame portion or the grip portion, of the racket frame. As a matter of fact, existing states are not limited to the abovementioned existing states.

[0015] In order to obtain the best use of vibration damping capacity and impact resistance of the fiber reinforced thermoplastic resin and environmental resistant properties of the fiber reinforced thermosetting resin, it is preferable to use the fiber reinforced thermoplastic resin in the frame portion and it is particularly preferable to use the fiber reinforced thermoplastic resin in the outer layer of the frame portion. The most vital point in the invention is that of the thermosetting resin and the thermoplastic resin or the thermosetting resin, the thermoplastic

resin and the reinforcing fibers are intermingled with each other at the boundary of the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin. Although the adhesive property between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin is not always good, the intermingled state serves to largely improve the adhesive property between them to prevent destruction due to peeling etc. between them. This makes the racket frame more durable and impact resistant.

[0016] To achieve a method for intermingling a thermosetting resin and a thermoplastic resin or a thermosetting resin, a thermoplastic resin and reinforcing fibers at the boundary of the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin, in a method for joining a frame portion formed with the fiber reinforced thermoplastic resin and a grip portion formed with the fiber reinforced thermosetting resin with an adhesive, a material in which a thermosetting resin and a thermoplastic resin compatible with each other coexist at the molecule level or both resins coexist with a microphase-separated structure which is formed by a combination of both resins that are compatible in the molten state but undergo phase separation as they are cured or coagulated, is can be used as the adhesive. It can also be effective to use, as the adhesive, a material produced by kneading both resins and reinforcing fibers such as whiskers and short fibers. It can also be effective to use, as the adhesive, an alloy or blend in which noncompatible thermosetting resin and thermoplastic resin coexist at the macro level to form a sea-and-islands structure or a domain structure, or to use, as the adhesive, a material produced by kneading reinforcing fibers into the alloy or blend. A compatible agent may be added to increase the adhesiveness between both resins by controlling the sea-and-islands structure or the domain structure. The thermosetting resin and thermoplastic resin used should preferably be the same as matrix resins in the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin, respectively.

[0017] Another method to achieve the coexistence is to prepare a foam havilng a porous structure or a nonwoven fabric having a network structure produced by spun-bonding,

melt-blowing, spun-lacing, etc., provide it at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin before molding, and impregnate the porous structure or network structure with the thermosetting resin or the thermoplastic resin. It is preferable that the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin originally have a porous structure or a network structure before molding, because the coexistence portion can be formed without using the foam or nonwoven fabric arranged at the boundary. The foam or nonwoven fabric may comprise a thermoplastic resin, a thermosetting resin, or either a thermoplastic resin or a thermosetting resin that contains reinforcing fibers, but the use of a thermoplastic resin or a fiber reinforced thermoplastic resin is preferable.

[0018] More specifically, there is a method for producing a molding material which comprises preparing a core comprising a heat-resistant tube (for instance, a rubber tube having high-extensibility such as silicone rubber and fluororubber, or a tube of infusible and heat-resistant polymer such as polyimide para-oriented aramid), cladding the heat-resistant tube with a fiber reinforced thermoplastic resin, further cladding its outer layer with a communicating porous thermoplastic resin sheet and a fiber reinforced thermosetting resin, placing it in a die, supplying liquid or gas into the heat-resistant tube for pressurization while heat-molding the molding material, and removing the heat-resistant tube from the molding material. The resin constituting the communicating porous thermoplastic resin sheet should preferably be the same as the matrix resin in the fiber reinforced thermoplastic resin. To allow the communicating pores to be impregnated with the matrix resin for the fiber reinforced thermosetting resin, the melting point or softening point of the communicating porous thermoplastic resin should preferably be not less than the temperature at which the viscosity of the matrix resin in the fiber reinforced thermosetting resin reaches the minimum while the resin is still in the uncured state, more preferably not less than the minimum viscosity temperature and not more than 300°C. The effect of providing the porous sheet will deteriorate if the

communicating pores are excessively impregnated with the matrix resin for the fiber reinforced thermosetting resin to allow the latter to reach the fiber reinforced thermoplastic resin. To avoid this, the molding conditions should be optimized. When the viscosity of the matrix resin for the fiber reinforced thermosetting resin before curing is measured while being heated at a constant heating rate, the ratio of the viscosity at 30°C to the minimum viscosity should preferably be 100 or less, more preferably 50 or less, and still more preferably 10 or less. Such resin can be obtained by adding an appropriate component or particles generally known to have thickening capability. For instance, the addition of Aerosil for thickening serves to obtain an intended resin. The viscosity at 30°C should be in the range of 1,000 to 50,000 poise, preferably 5,000 to 20,000 poise. Such a viscosity is preferable to simultaneously achieve a high handleability of the thermosetting fiber reinforced resin at room temperature and a high controllability of the flow behavior during the curing process. This problem will not take place and there are no specific limitations on the viscosity ratio when an adhesive as described above is used. A nonwoven fabric having a network structure may be used instead of the communicating porous thermoplastic resin sheet.

[0019] A tube of foamed synthetic resin or thermoplastic resin may be used as the core instead of the heat-resistant tube. The aforementioned examples place no limitations on the order of material cladding of the core. As molding material to produce the fiber reinforced thermoplastic resin, the use of a composite sheet comprising a sheet comprising an aggregate of reinforcing long fibers substantially uni-directionally arranged in the lengthwise direction of the fibers and a sheet comprising a thermoplastic fibers wherein the thermoplastic fibers are entered into and interlaced and integrated with the reinforcing long fibers and wherein the sheet comprising the thermoplastic fibers is a nonwoven fabric having a network structure or the use of a braid produced by processing the composite sheet into a tube is preferable. In such cases, it is not necessary to provide a thermosetting resin or thermoplastic resin of a porous structure or a network structure before molding at the boundary between the fiber

reinforced thermosetting resin and the fiber reinforced thermoplastic resin. Furthermore, it is particularly preferable to use a composite sheet comprising the thermoplastic fibers sheet which is placed only on one side of the aggregate of reinforcing long fibers in which both are interlaced and integrated, that is, a composite sheet in which the reinforcing long fibers are exposed on one side, because the reinforcing long fibers aggregate is impregnated with both thermoplastic resin and thermosetting resin and an area where the thermoplastic resin, the thermosetting resin and reinforcing long fibers are intermingled with each other is formed, leading to a high adhesiveness.

[0020]

[Examples] The invention is described below with reference to examples, though the examples are not intended to place any limitations on the invention. Characteristics of the racket frames produced by the following methods are shown in Tables 1 and 2.

1) : The head portion of a frame and a grip potion are fixed, and a bending load is applied to the top portion of the grip portion, followed by determining the bending fracture strength.

2) : The frame portion is hit with a hammer, followed by determining the inverse number of the time in hours required for the amplitude detected at the grip portion to decrease to 1/10 of the initial amplitude.

3) : The racket is dropped repeatedly with the frame portion down from a height of 1.5 m, followed by determining the number of repetitions required to fracture the racket.

4) : The grip portion is fixed, and a load to displace the top of the racket frame portion by 30 mm is applied repeatedly, followed by determining the number of repetitions required to fracture the racket.

[0021]

[Examples 1 and 2] To provide a tennis racket as shown in Figure 1, a frame portion 2 was produced by kneading polybutylene terephthalate resin with a 30 wt% amount of carbon fibers and injection-molding the resin at a cylinder temperature of 260°C, an injection pressure of

1,000 kg/cm^2 and a die temperature of 70°C. A grip portion was produced by pressing a carbon fiber reinforced epoxy resin under air pressure of 10 kg/cm^2 and curing it at 160°C for 20 min., followed by internal pressure molding. An adhesive consisting of an epoxy resin mixed with a 20wt% amount of a compatible copolymerized polyester resin was used to join the frame portion and the grip portion to provide a racket frame (Example 1). Furthermore, a 10 wt% amount of vapor-grown carbon fibers (fiber diameter 0.1μm, fiber length 20μm) was kneaded into the adhesive, and the resulting adhesive was used to join the frame portion and the grip portion to provide a racket frame (Example 2).

[0022]

[Comparative example 1] Except that epoxy resin was used alone as an adhesive, the same procedure as in Example 1 was carried out to provide a racket frame.

[0023]

[Example 3] A silicon tube was covered with a prepreg composed of reinforcing carbon fibers and an epoxy resin by a sheet winding method. A portion of thus obtained tube corresponding to a frame portion 2 was covered with a nonwoven fabric produced by a melt blowing of a maleic acid modified polypropylene resin. The frame portion 2 thus prepared was covered with a sheet produced by impregnating a carbon fiber aggregate in which carbon fibers were arranged in uni-direction along lengthwise direction of the fibers with a melted maleic acid modified polypropylene resin.

[0024] A preform thus produced was mounted on a racket frame metal mold. The preform was heated at 200°C for 20 minutes in a state that the silicon tube was pressured with 10 kg/m^2 of air pressure acted from the both ends thereof. After that, the preform was heated at 130°C for 30 minutes and thereby a racket frame was produced. After cooling the racket frame to a room temperature, the silicon tube was removed from the racket frame. Since a temperature showing the minimum viscosity of the matrix resin of the carbon fiber reinforced epoxy resin prepreg is about 120°C and the ratio of a viscosity at 30°C to the minimum

viscosity is about 25, the matrix resin flows in a state of softening in a temperature rising process up to 200°C and impregnates into a network structure of the nonwoven fabric, however the matrix resin does not reach the fiber reinforced thermoplastic resin sheet and remains in the nonwoven fabric, since the minimum viscosity of the matrix resin is high. Further, at about 160°C, the nonwoven fabric and the matrix resin of the fiber reinforced thermoplastic resin sheet are melted and unified with each other. As a result, a domain in which the thermosetting resin and the thermoplastic resin are intermingled each other in three dimensions and which is resulted from the network structure is formed at the boundary of the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[0025] Fig. 2 is a cross section taken along the line A-A of the frame portion of the racket frame. Fig. 3 is an enlarged exemplary diagram of the boundary of the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin.

[0026]

[Comparative Example 2] A racket frame was produced according to the same procedure as described for Example 3 except no covering with the nonwoven fabric produced by a melt blowing of a maleic acid modified polypropylene resin. The fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin showed a clear interface between them and a domain in which the thermosetting resin and the thermoplastic resin are intermingled each other did not exist.

[0027]

[Examples 4 and 5] A silicon tube was covered with a carbon fiber reinforced epoxy resin prepreg by a sheet winding method. In addition, a nonwoven fabric of meltblown maleic acid modified polypropylene resin was provided over both sides (Example 4) or one side (Example 5) of a carbon fiber aggregate comprising fibers substantially uni-directionally arranged in the lengthwise direction of the fibers. A high pressure water stream was applied to allow the fibers of the maleic acid modified polypropylene resin to get into the carbon fiber aggregate to

ensure their integration into a composite sheet, which was then subjected to a sheet winding to cover the portion corresponding to the frame 2. This perform was placed in a racket frame die. While applying an air pressure of 10 kg/mm^2 from both ends of the silicon tube, it was heated at 200°C for 20 min and then heated at 130°C for 30 min to provide a racket frame. The silicon tube was removed from the racket frame after cooling to room temperature. The matrix resin in the carbon fiber reinforced epoxy resin prepreg showed its minimum viscosity at a temperature about 120°C and the ratio of the viscosity at 30°C to the minimum viscosity was about 25. In Example 4, the matrix resin softens and flows in the heating process up to 200°C to impregnate a network structure in the nonwoven fabric. However, as its minimum viscosity is rather high, it stays in the nonwoven fabric instead of reaching the carbon fibers in the thermoplastic fiber reinforced resin sheet. Then at about 160°C, the matrix resin in the fiber reinforced thermoplastic resin sheet melts to impregnate the carbon fibers and the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin are integrated. As a result, an area where the thermosetting resin and the thermoplastic resin are interlaced and intermingled three dimensionally that originates in the network structure is formed at the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin. In Example 5, the fiber reinforced thermosetting resin prepreg is contact with a carbon fiber exposed surface of the fiber reinforced thermoplastic resin sheet in which the carbon fibers are exposed, allowing the carbon fibers to be contained in an area where the thermosetting resin and the thermoplastic resin are interlaced and intermingled each other in a three-dimensional state. This leads to the formation of a stronger boundary. Figure 4 shows an enlarged view of the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin in Example 5.

[0028]

[Comparative example 3] Only a carbon fiber reinforced epoxy resin was used to produce a racket frame.

[0029]

[Effect of the Invention] The invention aims to allow a fiber reinforced thermoplastic resin to coexist with a fiber reinforced thermosetting resin while making the best use of the high vibration damping capacity and good impact resistant properties of the former and preventing the loss of the high environmental resistance and other good characteristics of the latter. To this end, the composition and structure of the boundary are controlled to largely improve the adhesiveness and strength of the boundary. Thus, the racket frame of fiber reinforced resin of the invention is characterized by having high vibration damping capacity and good feel at impact and suffering little change under varying use conditions while maintaining sufficient practical strength, rigidity and durability.

[0030]

[Table 1]

		Strength[1]		Vibration damping[2]		Impact resistance[3]		Durability[4]	
		20°C	40°C	20°C	40°C	20°C	40°C	20°C	40°C
Example	1	103	90	99	104	119	110	106	98
	2	103	93	97	100	122	116	111	104
Comparative example	1	100	81	100	104	100	92	100	85

All characteristics are shown in percentages relative to the measurements made at 20°C in Comparative example 1.

[0031]

[Table 2]

		Strength[1]		Vibration damping[2]		Impact resistance[3]		Durability[4]	
		20°C	40°C	20°C	40°C	20°C	40°C	20°C	40°C
Example	3	96	90	395	425	136	140	128	134
	4	98	92	389	420	140	147	130	135
	5	100	92	371	406	149	155	140	143
Comparative example	2	97	90	360	410	120	122	115	117
	3	100	92	100	110	100	103	100	98

All characteristics are shown in percentages relative to the measurements made at 20°C in Comparative example 3.

[Brief description of the drawings]

[Figure 1] A front view of a tennis racket.

[Figure 2] The A-A cross-sectional view in Example 3.

[Figure 3] An enlarged schematic diagram of the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin in the A-A cross section in Example 3.

[Figure 4] An enlarged schematic diagram of the boundary between the fiber reinforced thermosetting resin and the fiber reinforced thermoplastic resin in the A-A cross section in Example 5.

[Explanation of reference signs]

1: racket frame

2: frame portion

3: grip portion

4: fiber reinforced thermosetting resin

5: fiber reinforced thermoplastic resin

6: thermosetting resin

7: thermoplastic resin

8: carbon fibers

9: hollow portion

10: Area where thermosetting resin and thermoplastic resin are intermingled with each other or where thermosetting resin, thermoplastic resin and carbon fibers are intermingled with each other

Fig. 1

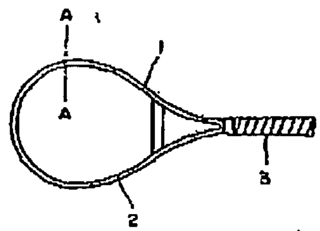

Fig. 2

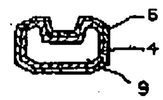

Fig. 3

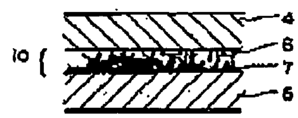

Fig. 4